

## CLAIMS

1. An azimuth measuring device comprising:

earth magnetism detection means with 2 or 3 axes for  
5 detecting earth magnetism;

output data acquisition means for acquiring 2-axis output  
data when the orientation of said earth magnetism detection  
means changes while keeping the detection directions of said  
two axes on a predetermined plane or 3-axis output data when  
10 the orientation of said earth magnetism detection means changes  
in a three-dimensional space repeatedly a predetermined number  
of times or more;

reference point estimation means for defining a reference  
point on a two-dimensional coordinate system whose coordinate  
15 values correspond to said 2-axis output data or on a  
three-dimensional coordinate system whose coordinate values  
correspond to said 3-axis output data and estimating the  
coordinates of reference point using a statistical technique  
so that a variation in the distance from the 2-axis or 3-axis  
20 output data group acquired by said output data acquisition  
means to the reference point becomes a minimum; and

offset information calculation means for calculating  
offset information with respect to the output data of said  
earth magnetism detection means based on said coordinates of  
25 reference point.

2. The azimuth measuring device according to claim 1, characterized in that said reference point estimation means comprises:

coefficients and constant term calculation means for  
5 calculating coefficients and constant terms of simultaneous linear equations whose unknowns are said coordinates of reference point from said 2-axis or 3-axis output data group; and

simultaneous linear equation analysis means for  
10 estimating said coordinates of reference point by calculating solutions to said simultaneous linear equations including said coefficients and constant terms.

3. The azimuth measuring device according to claim 1, characterized in that said earth magnetism detection means is 3-axis earth magnetism detection means, and

when a degree of the variation of the output data group is a predetermined value or below with respect to the output data group of the axis whose degree of variation is a minimum  
20 out of the 3-axis output data group, said reference point estimation means defines a reference point on a two-dimensional coordinate system whose coordinate values correspond to the 2-axis output data for the 2-axis output data group which is generated by excluding the output data group of the axis whose  
25 degree of variation is a minimum from said 3-axis output data group and estimates said coordinates of reference point from said 2-axis output data group.

4. The azimuth measuring device according to claim 1, characterized in that said reference point estimation means comprises:

first difference calculation means for calculating a  
5 difference between a maximum value and minimum value of output data in the output data group of each axis from said 2-axis or 3-axis output data group; and

first difference decision means for deciding whether the difference calculated by said first difference calculation  
10 means is equal to or greater than a predetermined value or not, and

said reference point estimation means uses said 2-axis or 3-axis output data group for estimating said reference point only when the difference calculated by said first difference  
15 calculation means is equal to or greater than a predetermined value.

5. The azimuth measuring device according to claim 1, characterized in that said offset information calculation  
20 means comprises:

variation calculation means for calculating a variation at a predetermined number of the latest reference points calculated by said reference point estimation means, and

said offset information calculation means discards the  
25 reference point calculated by said reference point estimation means based on the calculation result of said variation calculation means.

6. The azimuth measuring device according to claim 5, characterized in that said variation calculation means calculates the difference between the two latest reference points calculated by said reference point estimation means.

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7. The azimuth measuring device according to claim 1, further comprising:

second variation calculation means for calculating a variation at a predetermined number of the latest reference points calculated by said reference point estimation means;  
10 and

acceptability information creation means for creating acceptability information regarding the acceptability of said offset information based on the calculation result of said  
15 second variation calculation means.

8. The azimuth measuring device according to claim 7, characterized in that said acceptability information creation means divides the degree of acceptability of said offset  
20 information into a plurality of categories, classifies the offset information into any one of said categories according to the degree of variation calculated by said second variation calculation means and displays the degree of acceptability corresponding to the category.

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9. The azimuth measuring device according to claim 1, characterized in that said offset information calculation means comprises:

distance calculation means for calculating the distance from said output data group to said reference point; and

distance decision means for deciding whether the distance calculated by said distance calculation means is outside a  
5 predetermined range or not, and

said offset information calculation means discards the output data group when the distance calculated by said distance calculation means is outside the predetermined range.

10 10. The azimuth measuring device according to claim 1, further comprising:

second distance calculation means for calculating the distance from said output data group to said reference point; and

15 reliability information creation means for creating reliability information regarding the reliability of the azimuth measurement result based on the distance calculated by said second distance calculation means.

20 11. The azimuth measuring device according to claim 10, characterized in that said reliability information creation means divides the degree of reliability of said azimuth measurement result into a plurality of categories, compares the distance calculated by said second distance calculation  
25 means with a plurality of thresholds, classifies the distance into any one of said categories and displays the degree of reliability corresponding to the category.

12. The azimuth measuring device according to claim 1, characterized in that said data output acquisition means comprises:

5 third difference calculation means for calculating a difference between the output data output from said earth magnetism detection means and a predetermined number of pieces of immediately preceding output data acquired by said output data acquisition means or the output data output immediately before from said earth magnetism detection means; and

10 third difference decision means for deciding whether the difference calculated by said third difference calculation means is smaller than a predetermined value or not, and

said output data acquisition means does not acquire but discards the output data output from said earth magnetism detection means when the difference calculated by said third difference calculation means is smaller than the predetermined value.

13. An azimuth measuring method including:

20 a step of changing detection directions of two axes for measurement of earth magnetism while keeping the detection directions of two axes on a predetermined plane or changing the detection directions of three axes in a three-dimensional space;

25 a step of acquiring the 2-axis or 3-axis output data for measurement of earth magnetism when said detection directions change;

a step of deciding whether said output data is acquired a predetermined number of times or more or not;

a step of defining a reference point on a two-dimensional coordinate system whose coordinate values correspond to said  
5 2-axis output data or on a three-dimensional coordinate system whose coordinate values correspond to said 3-axis output data and estimating the coordinates of reference point using a statistical technique so that a variation in the distance from the output data group consisting of the 2-axis or 3-axis output  
10 data acquired said predetermined number of times or more to the reference point becomes a minimum; and

a step of calculating offset values with respect to said 2-axis or 3-axis output data based on said estimated coordinates of reference point.

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14. The azimuth measuring method according to claim 13, characterized in that said step of estimating the coordinates of reference point comprises:

a step of calculating coefficients and constant terms  
20 of simultaneous linear equations whose unknowns are said coordinates of reference point from said 2-axis or 3-axis output data group; and

a step of calculating solutions to said simultaneous linear equations including said coefficients and constant  
25 terms and estimating said coordinates of reference point.

15. The azimuth measuring method according to claim 13, characterized in that said step of changing said detection

direction is intended to change detection directions of three axes in a three-dimensional space, and

said step of estimating the coordinates of reference point comprises:

5        a step of calculating the degree of variation of output data of the output data group of each axis of said 3-axis output data group and obtaining the axis corresponding to the minimum degree of variation and a minimum value of said degree of variation,

10       a step of deciding whether said minimum value of the degree of variation is equal to or lower than a predetermined value or not; and

      a step of defining, when said minimum value of the degree of variation is equal to or lower than the predetermined value,  
15       a reference point on a two-dimensional coordinate system whose coordinate values correspond to the 2-axis output data for the 2-axis output data group wherein the output data group of the axis whose degree of variation becomes a minimum is excluded from said 3-axis output data group and estimating  
20       said coordinates of reference point from said 2-axis output data group.

16. The azimuth measuring method according to claim 13, characterized in that said step of estimating the coordinates  
25       of reference point comprises:

      a step of calculating the difference between a maximum value and minimum value of output data of the output data group of each axis of said output data group;



a step of deciding whether the difference between said maximum value and minimum value is equal to or greater than a predetermined value or not; and

5 a step of estimating said coordinates of reference point when said difference between the maximum value and minimum value is equal to or greater than the predetermined value.

17. The azimuth measuring method according to claim 13, characterized in that the step of calculating offset values with respect to said 2-axis or 3-axis output data comprises:

10 a step of calculating a variation at a predetermined number of the latest reference points calculated in the step of estimating the coordinates of reference point; and

a step of discarding the reference point calculated in the step of estimating the coordinates of reference point based on the calculation result of said variation.

18. The azimuth measuring method according to claim 13, further comprising:

20 a step of calculating a variation at a predetermined number of said estimated latest coordinates of reference points; and

a step of creating acceptability information regarding the acceptability of the offset values calculated in said step of calculating said offset values based on the calculation result of said variation.

19. The azimuth measuring method according to claim 13, characterized in that the step of calculating offset values with respect to said 2-axis or 3-axis output data comprises:

5 a step of calculating the distance from said output data group to said reference point;

a step of deciding whether the distance from said output data group to said reference point is outside a predetermined range or not; and

10 a step of discarding the output data group when the distance from said output data group to said reference point is outside the predetermined range.

20. The azimuth measuring method according to claim 13, further comprising a step of calculating the distance from  
15 said output data group to said reference point; and

a step of creating reliability information regarding the reliability of the azimuth measurement result based on said distance calculation result.